LUI

School code $\square$

School name $\square$
$\square$


External assessment 2022


## Engineering

## Time allowed

- Perusal time - 10 minutes
- Working time - 120 minutes


## General instructions

- Answer all questions in this question and response book.
- QCAA-approved calculator permitted.
- Protractor and ruler required.
- QCAA formula and data book provided.
- Planning paper will not be marked.


## Section 1 (10 marks)

- 10 multiple choice questions


## Section 2 (41 marks)

- 7 short response written questions


## Section 3 (34 marks)

- 5 short response calculation questions


## DO NOT WRITE ON THIS PAGE

THIS PAGE WILL NOT BE MARKED

## Section 1

## Instructions

- Choose the best answer for Questions 1-10.
- This section has 10 questions and is worth 10 marks.
- Use a 2B pencil to fill in the A, B, C or D answer bubble completely.
- If you change your mind or make a mistake, use an eraser to remove your response and fill in the new answer bubble completely.


[^0]
## Section 2

## Instructions

- Write using black or blue pen.
- Respond in paragraphs consisting of full sentences.
- If you need more space for a response, use the additional pages at the back of this book.
- On the additional pages, write the question number you are responding to.
- Cancel any incorrect response by ruling a single diagonal line through your work.
- Write the page number of your alternative/additional response, i.e. See page ...
- If you do not do this, your original response will be marked.
- This section has seven questions and is worth 41 marks.


## DO NOT WRITE ON THIS PAGE

## THIS PAGE WILL NOT BE MARKED

## QUESTION 11 (5 marks)

Explain the concepts of mechanical advantage and velocity ratio using a simple pulley system. Provide an annotated sketch to support your response.


Note: If you make a mistake in the sketch, cancel it by ruling a single diagonal line through your work and use the additional response space at the back of this question and response book.
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$

Do not write outside this box.

## QUESTION 12 (4 marks)

State four industrial applications for carbon steel with $0.15 \%$ to $0.30 \%$ carbon content.

1. $\qquad$
2. $\qquad$
3. $\qquad$
4. $\qquad$

## QUESTION 13 (5 marks)

Describe the function of a NAND gate. Include a truth table to support your response.
$\square$
Note: If you make a mistake in the truth table, cancel it by ruling a single diagonal line through your work and use the additional response space at the back of this question and response book.
$\qquad$
$\qquad$
$\qquad$
$\qquad$

Do not write outside this box.

## QUESTION 14 (6 marks)



Use the information included in the lead-tin thermal-equilibrium phase diagram to identify each key feature.
I) solidus line $\qquad$
II) liquidus line $\qquad$
III) eutectic point $\qquad$
IV) eutectic temperature $\qquad$
V) maximum solubility of lead in tin $\qquad$
VI) maximum solubility of tin in lead $\qquad$

[^1]
## QUESTION 15 (6 marks)

Contrast the suitability of mild and high carbon steel for applications in the manufacture of automotive subframes that experience repeated loads and high impacts, using their microstructure and three relevant mechanical properties.

[^2]
## QUESTION 16 (10 marks)

The ceiling fans in a meeting room operate on demand. When staff access the room using a swipe card and the temperature in the room is above $25^{\circ} \mathrm{C}$, the fans turn on, activating a one-hour timer. The fans then turn off after one hour of operation, unless a movement sensor is activated, resetting the timer to keep the fans on for another hour.

Analyse this information to create a logic circuit that meets the requirements for ceiling fan operation. Clearly identify all inputs and outputs.
$\square$
Note: If you make a mistake in the logic circuit, cancel it by ruling a single diagonal line through your work and use the additional response space at the back of this question and response book.

## QUESTION 17 (5 marks)

Nylon can be used in the manufacture of industrial gears. The stress-strain diagram indicates the effect adding epoxidised natural rubber (ENR) has on the mechanical properties of nylon.


Interpret the data to explain how adding different percentages of ENR to nylon influences its effectiveness for gear manufacture. Include four relevant mechanical properties to support your response.
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$

Do not write outside this box.
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$

## Section 3

## Instructions

- Respond showing full working for calculations.
- This section has five questions and is worth 34 marks.


## DO NOT WRITE ON THIS PAGE

THIS PAGE WILL NOT BE MARKED

Do not write outside this box.

## QUESTION 18 (5 marks)

Determine the force required to launch a rocket with a mass of 2000 kg vertically from rest to a height of 20 km in 20 seconds. Assume that the rocket's mass and acceleration due to gravity remain constant during the launch and that air resistance is not a factor.
Include a free-body diagram showing the forces at launch. Answer to the nearest whole unit in kN .

Note: If you make a mistake in the diagram, cancel it by ruling a single diagonal line through your work and use the additional response space at the back of this question and response book.

[^3]
## QUESTION 19 (9 marks)

An empty cable car with a mass of 1500 kg is being lowered down a track on a $25^{\circ}$ incline at a constant velocity of $2 \mathrm{~m} / \mathrm{s}$ when the cable snaps, releasing the cable car. The cable car's emergency braking system engages when its velocity reaches $5 \mathrm{~m} / \mathrm{s}$ and increases the coefficient of friction between the cable car and the track from 0.01 to 0.6 , bringing it to a complete stop. A warning siren activates when the cable car is 10 metres from the original point of cable failure if it has not come to a stop.

Determine the stopped position of the cable car relative to the warning siren's activation point. Answer to the nearest whole unit in metres.

Do not write outside this box.
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$

## QUESTION 20 (6 marks)

A pulley system moves a generator with a mass of 300 kg up a $15^{\circ}$ incline. The coefficient of static friction between the incline and the generator is 0.3 .

## Not to scale



Determine the tension in the pulley rope required at E to almost begin moving the generator up the incline if the pulley system is $80 \%$ efficient. Answer to two decimal places.

Assume that the pulley system is parallel to the incline.
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$

Do not write outside this box.

## QUESTION 21 (5 marks)

Determine the percentage of the liquid components for an alloy containing $65 \%$ lead at a temperature of $250^{\circ} \mathrm{C}$. Annotate the lead-tin equilibrium phase diagram as part of your response.


Note: If you make a mistake in the diagram, cancel it by ruling a single diagonal line through your work and use the additional response space on page 25 of this question and response book.
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$

Do not write outside this box.

## QUESTION 22 (9 marks)

An airport luggage handling system consists of three connected sections.

- Section 1: Luggage slides away from the aircraft down a 25 -metre-long steel ramp set at $45^{\circ}$ to the horizontal.
- Section 2: Luggage travels along a 45 -metre-long motorised horizontal conveyor.
- Section 3: Luggage travels along a 30-metre-long motorised variable-speed horizontal conveyor before reaching the luggage carousel.


## Section 3 conveyor



Determine the revolutions per minute (rpm) of the variable-speed conveyor motor in Section 3 if the coefficient of kinetic friction $\left(\mu_{k}\right)$ between luggage and steel is 0.42 and the luggage

- takes 20 seconds to move from the aircraft to the carousel
- spends half as long in Section 2 as Section 3.

Answer to the nearest whole unit. State any assumptions made.

Do not write outside this box.
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$

END OF PAPER

## ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$

Do not write outside this box.

## ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$

Do not write outside this box.

## ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$

Do not write outside this box.

## ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$

Do not write outside this box.

## ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

## ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

[^4]
## ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

## ADDITIONAL RESPONSE SPACE FOR QUESTION 21

If you want this diagram to be marked, rule a single diagonal line through the diagram on page 15 .


## References

## Question 17

Adapted (QCAA has labelled the top line ' $0 \%$ ENR) from Fig 2 in Tanrattanakul, V, Sungthong, N and Raksa, P 2008, 'Rubber toughening of nylon 6 with epoxidized natural rubber', Polymer Testing, vol. 27, issue 7, pp. 794-800, https://doi.org/10.1016/j.polymertesting.2008.05.013

## Question 20

## Adapted from:

Igiritam 2015, 'Which diesel generators have make resale value?', Wikimedia Commons, https://commons. wikimedia.org/wiki/File:Which_Diesel_Generators_Have_Make_Resale_Value\%3F.jpg, CC BY 4.0

Игоревич 2009, 'Old engine-generator AB-2', Wikimedia Commons, https://commons.wikimedia.org/ wiki/File:Old_engine-generator_AB-2.jpg, Public domain

Prolineserver, T 2006, 'Four pulleys', Wikimedia Commons, https://commons.wikimedia.org/wiki/ File:Four_pulleys.svg, CC BY 3.0

## Question 22

Inspired by KevinHannessen 2016, 'Inclined-belt conveyor', Wikimedia Commons, https://commons. wikimedia.org/wiki/File:Inclined-belt_conveyor.jpg, CC BY 4.0

Licence: https://creativecommons.org/licenses/by/4.0 | Copyright notice: www.qcaa.qld.edu.au/copyright — lists the full terms and conditions, which specify certain exceptions to the licence. Third-party materials referenced above are excluded from this licence.
Attribution: © State of Queensland (QCAA) 2022


[^0]:    Do not write outside this box.

[^1]:    Do not write outside this box.

[^2]:    Do not write outside this box.

[^3]:    Do not write outside this box.

[^4]:    Do not write outside this box.

